

MICRODEFORMATION IN VREDEFORT ROCKS - EVIDENCE FOR SHOCK METAMORPHISM? W.U. Reimold, M.A.G. Andreoli* and R.J. Hart*, Schonland Research Centre for Nuclear Sciences, University of the Witwatersrand, Wits 2050, Johannesburg, RSA; *on secondment from the Atomic Energy Corporation, Pelindaba.

Planar microdeformations in quartz from basement or collar rocks of the Vredefort Dome have been cited for years (e.g.(1,2)) as the main microtextural evidence for shock metamorphism in this structure. In addition, Schreyer (2) describes feldspar recrystallization in rocks from the centre of the Dome as the result of transformation of diaplectic glass, and Lilly (1) reported the sighting of mosaicism in quartz. These textural observations (and others, cf. (3)) are widely believed to indicate either an impact or an internally produced shock origin for the Vredefort Dome.

Two types of (mostly sub)planar microdeformations are displayed in quartz grains from Vredefort rocks: (a) fluid inclusion trails, and (b) straight optical discontinuities that sometimes resemble lamellae. Both types occur as single features or as single or multiple sets in quartz grains. Lilly (1) found second-generation features crosscutting annealed sets of first-generation fractures. Recently Reimold (4,5) identified type (b)- features as (sub)planar open fractures. These fractures are clearly distinct from typical planar elements (shock lamellae, (6)) that differ in length, spacing and isotropism from Vredefort fractures. Moreover, planar elements as defined were never positively identified in Vredefort rocks, though fluid inclusion trails have been interpreted (2,7) as decorations of annealed planar elements.

The contention that the degree of shock deformation increases towards the centre of the Vredefort Dome (2,8) has been disputed by Hart and Andreoli (9,10) and by Reimold (4). These authors describe a maximum density of planar fractures within the pseudotachylite-rich zone (Vredefort Discontinuity) which abruptly separates the amphibolite-facies Outer Granite Gneiss suite from a core terrane of lower crustal charnockites and granulites (Inlandsee Leucogranofels).

In 1987, Robertson, Grieve and co-workers (7) determined crystallographic orientations of type(a) and (b) features in Vredefort rocks. Assuming that type(a) features represented annealed planar elements they concluded that there was some evidence for shock metamorphism at Vredefort and limited evidence for increase of shock pressure towards the centre of the Dome.

THIS STUDY: Besides qualitative descriptions of cleavage and recrystallization in feldspar and kinkbands in mica (1,2) no further microtextural evidence for shock metamorphism at Vredefort has been reported to date.

We re-examined some 150 thin sections of Vredefort basement rocks for potential shock and other deformation effects in all rock-forming minerals. This included petrographic study of two drill cores from the immediate vicinity of the centre of the Dome.

RESULTS: The following observations have been recorded throughout the granitic core: 1. The southern portion of the Dome is characterized by a conspicuous paucity of planar microdeformations in quartz. They are however observed in association with pseudotachylite (that is equally rare in the south) or shear faults. In addition, Lilly's findings (1) of two generations of quartz microdeformations have been confirmed by us. The assumption that fluid inclusion trails represent annealed planar elements cannot be supported, as frequently relics of open fractures are observed along the trails. 2. Kinkbanding in biotite has a similar distribution to the brittle deformation in quartz and

feldspar (4) across the basement, with maximum deformation being displayed in the pseudotachylite-rich zone. 3. Feldspar deformation is generally restricted to cleavage, irregular fracturing and rare undulatory extinction. Locally, at the Vredefort discontinuity microlithic recrystallization of plagioclase is encountered. 4. Mechanical twinning in hornblende or pyroxene, planar lamellae in feldspar, or planar fractures and mosaicism in olivine were never observed. Only one apatite grain from near to the Discontinuity displayed one set of planar fractures $\parallel(0001)$. 5. Samples collected in the vicinity of the centre of the structure are strongly recrystallized. But the unannealed portions (up to 50% of a thin section) do not exhibit shock metamorphic effects. Type(a) and (b) microdeformations in quartz, however, can still be frequently observed. Occasionally quartz grains in Central Intrusive Granite (11) display planar fractures and fluid inclusion trails.

6. Interbanded noritic granulite and Inlandsee Leucogranofels in the Oakdale borehole and hornblende-peridotite in the Beta borehole just north of the Inlandsee (centre of structure) display several shallow and, less frequently, subvertically dipping, often glimmeritic shear zones. Mineral deformation in the boreholes is generally limited, but is obviously enhanced in and along the shear zones. Deformation effects observed in the rock-forming minerals are: (a) quartz is widely recrystallized and only to a minor extent displays irregular fracturing. (Sub)planar trails of fluid inclusions or fractures were never observed; (b) plagioclase only displays cleavage, irregular fracturing and sometimes wavy extinction; (c) amphibole and pyroxene show cleavage, wavy extinction and (micro)kinking; (d) mica is occasionally kinkbanded; (e) polygonisation (not mosaicism!) is sometimes seen in pyroxene and olivine that also commonly display deformation bands. No shock metamorphic effects (e.g. mechanical twinning, mosaicism) have been observed in the mafic minerals of the boreholes.

CONCLUSIONS: 1. From this regional survey it appears that the most deformed rocks are associated with the Vredefort Discontinuity and are not found at the centre of the structure. 2. Shock deformation effects that would be characteristic for shock pressures up to 20 GPa (as postulated by (7) for the centre of the Dome) are completely absent. 3. Deformation effects observed are not diagnostic of shock metamorphism, but could also be formed by high-strain tectonic processes. 4. Planar fractures like those observed in Vredefort are found associated with pseudotachylite from tectonic, cryptoexplosion and impact crater settings (12, 13).

Furthermore, the controversy on the nature of planar microdeformations in quartz from Vredefort bears on the discussion of mineralogical evidence for the cause of catastrophies in the stratigraphic record. In this respect it is mandatory to rigorously characterize the nature of planer "features" in quartz grains from the K-T boundary as compared to those of possible explosive volcanic origin.

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